

B1 to about 500, preferably from about 50 to about 250. The cycloaliphatic epoxy resins have a viscosity less than about 1000 cps (centipoise) at 25°C, preferably about 5 to about 900 cps, more preferably about 300 to about 600 cps, and most preferably about 300 to about 450 cps. The cycloaliphatic epoxy resins have a molecular weight of from about 200 to 700, preferably 200 to 500, and a weight per epoxide of 50 to 500, preferably 50 to 300.

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**The following paragraph replaces the paragraph on page 25, lines 22, 28, 29, 30 and 32:**

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B2 Preferably, the resin-photoinitiator-filler compositions or blends of the present invention further include a toughening agent to improve the fracture properties of the compositions. The toughening agent is preferably miscible with or capable of forming a stable suspension in the compositions. Further, when added to the compositions, the toughening agent preferably does not interfere with the cationic curing mechanism of the compositions and does not significantly affect the thermal and mechanical properties of the cured resin compositions. To achieve high glass transition temperatures and improve mechanical properties, e.g., toughness, the resin compositions preferably include toughening agents that have options such as thermoplastics, hydroxy-containing thermoplastic oligomers, epoxy or other organic functional reactive-containing thermoplastic oligomers, reactive flexibilizer, rubber, elastomer, or any mixtures thereof. A variety of toughening agents can be used with thermally or cationic cured epoxy resins, which typically use an amine coreactant or hardener for cross linking. Preferred toughening agents include rubber or elastomers, either as discrete particles or reacted with the epoxy resins, epoxy functionalized flexibilizers, engineering thermoplastics, and amine or hydroxy-terminated thermoplastic oligomers.

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**The following paragraph replaces the paragraph on page 26, line 4:**

B3  
The toughening agents and flexibilizers can benefit from high molecular weight engineering thermoplastics for increasing the toughness of the thermally or radiatively cured epoxy or epoxy-triazine mixtures utilized as binding matrices. Polysulfones such as those available from Amoco Performance Products, Inc. under the trademarks UDEL and RADEL can be dissolved in the epoxy resin-initiator composition to form a viscous homogeneous mixture. After curing, its toughness is significantly superior in comparison with the untoughened resin. Similar results can be obtained with a polyetherimide, which is available from General Electric Company under the trademark ULTEM. Although preferred the thermoplastic is not necessary to be miscible with the triazine or triazine epoxy resin-initiator composition. The fracture toughness of the cured resin can be further improved by adding Nylon 12 and Nylone 6/12 particles, ELF ATOCHEM ORGASO 2001 and ORGASOL 3501, or IMITEC X-902 polyimide particles, even though these materials are so insoluble in the epoxy resin monomer mixture. Other thermoplastics such as, for example, polyamideimides, poly(arylene ethers), polyesters, polyarylates, polycarbonates, polyurethanes etc., are potentially useful as toughening agents in accordance with the present invention. Further examples can be found in "Engineering Plastics" by D.C. Clagett in Encyclopedia of Polymer Science and Engineering, John Wiley and Sons.

**The following paragraph replaces the paragraph on page 26, lines 24 and 27:**

B4  
Engineering thermoplastics are typically end capped with nonreactive functional groups. In accordance with the embodiment of the present invention, the toughening agent is preferably a low molecular weight segment of oligomer of the aforementioned thermoplastics, which contains

B4  
functional groups capable of reaction with the cyanate or epoxy-cyanate resin during the radiation induced polymerization. Accordingly, thermoplastic materials that have been modified to contain a thermoplastic oligomer backbone and to have more reactive end groups are particularly useful as the toughening agents. For this purpose, hydroxy-terminated polysulfone oligomers based on the UDELP-1700 polymer backbone can be synthesized at various molecular weights. These materials can be easily blended with the resin monomer-photoinitiator mixture and the resulting compositions are less viscous than those having the same percentage of high molecular weight polymer of similar backbone, but with different end groups. The materials are also effective in increasing fracture toughness of the cured resin. Oligomers with other backbones such as, for example, poly (arylene ethers), polyarylates, and polyester, can also be used. In accordance with the present invention, any of the aforementioned thermoplastics could function as the oligomer backbone.

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**The following paragraph replaces the paragraph on page 27, lines 9 and 29:**

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B5  
Reactive end groups are capable of reacting with the cyanate-epoxy resin during the cationic polymerization. By way of example, the reactive end groups of the present invention include hydroxy, epoxy, and carboxylate groups. Flexible molecules containing two or more epoxy groups can also be used as the toughening agents in the present invention. These molecules typically contain long aliphatic groups that act to reduce cross link density in the cured epoxy resin. In addition to increasing the fracture toughness of the cured resin, the addition of low viscosity flexibilizers can also significantly the overall viscosity of the uncured resin-initiator-flexibilizer mixture. Suitable flexibilizers for the present invention include, but are not limited to, 1,4-butanediol diglycidyl ethers such as those from Shell Chemical Company under the trademark HELOXY

B5  
MODIFIER 67, neopentylglycol diglycidyl ether such as that from Shell Chemical Company under the trademark HELOXY MODIFIER 107, trimethylol ethane triglycidyl ethers such as those from Shell Chemical Company under the trademark HELOXY MODIFIER 44, dibromoneopentylglycol glycidyl ethers such as those from Shell Chemical Company under the trademark HELOXY MODIFIER 56, propoxylated glycerol polyglycidyl ether such as that from Shell Chemical Company under the trademark HELOXY MODIFIER 84, polypropylene glycol glycidyl ether such as that from Shell Chemical Company under the trademark HELOXY MODIFIER 32, polyglycidyl ether of castor oil such as that from Shell Chemical Company under the trademark HELOXY MODIFIER 505, dimer acid diglycidyl esters such as those from Shell Chemical Company under the trademark HELOXY MODIFIER 71, resorcinol diglycidyl ether such as that from Shell Chemical Company under the trademark HELOXY 59, epoxidized propylene glycol dioleates such as that under the trademark ELF ATOCHEM VIKOFLES 4050, 1,2-tetradecane oxides such as those under the trademark ELF ATOCHEM VIKOFLES 14, internally epoxidized 1, 3-butadiene homopolymers such as those under the trademarks ELF ATOCHEM POLY BD 600 and POLY BD 605, diglycidyl ether, glycidyl glycidates, bis (2, 3-epoxy-2 methypropyl) ether, and polyglycoldiepoxydes such as those from DOW Chemical Company under the trademarks DER 732 and DER 736. Flexible molecules containing two or more hydroxy groups can also be used as the toughening agents in accordance with the present invention. These flexible polyol compounds contain long aliphatic groups. Useful polyols include E-caprolactone triol such as those from Union Carbide Corporation under the trademarks TONE 0301, TONE 0305, and TONE 0310.

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**The following paragraph replaces the paragraph on page 28, line 7:**

B6  
Elastomeric units such as elastomers or rubbers that can be used in the composition of the present invention include, but are not limited to, copolymers of styrene, butadiene, and ethylene or styrene, butylene, and ethylene such as that from Shell Chemical Company under the trademark CRATON RUBBER, butadiene, styrene copolymers, copolymers of butadiene and styrene, butyl rubber, neoprene rubber, and poly (siloxanes). Functionalized versions of these materials are particularly useful. Epoxy resin monomers may be reacted with these materials to form an epoxy terminated elastomer that can be used as toughening agents. Maleic anhydride terminated KRATON rubber, e.g., Fg 1901X from Shell Chemical Company, and epoxy functionalized liquid KRATON rubber, e.g., EXP-206 and EKP-207 from Shell Chemical Company, can also be used as the toughening agents.

**The following paragraph replaces the paragraph on page 28, line 24:**

B7  
It is also advantageous to blend various types of toughening agents or flexibilizers in order to achieved desirable toughness through different toughening mechanisms and to adjust the overall viscosity of a thermoplastics or thermoplastic oligomer dissolved in an epoxy resin monomer. The overall viscosity may be reduced and the toughness may be improved in comparison with using a single toughening agent or flexibilizer. The thermoplastics may separate from the cured epoxy-cyanate resin to form a two phase morphology while the flexibilizer provides long flexible groups connect cross link sites in the network.

**The following paragraph replaces the paragraph on page 28, line 26:**

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B8 Elastomeric units which are endcapped with reactive functional groups can be used as the toughening agents. For example, fluoridized rubbers and polysiloxanes with terminally functional groups and hydroxylated or carboxylated EPDM rubber can also be used as the toughening agents in accordance with the present invention.

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